25X1

Modeling the Soviet Economy: SOVSIM After Six Years

25X1

A Technical Intelligence Report

SOV 85-10131
July 1985

Copy

25X1

Modeling the Soviet Economy: SOVSIM After Six Years

25X1

Overview

Information available as of 15 June 1985 was used in this report.

SOVSIM is a model of the Soviet economy. Using information and assumptions about the structure of the economy, resource availability, and economic policies, it can simulate the economy's operation and project its growth. It is designed primarily to make medium- to long-term projections—typically three to 10 years beyond the current year. Other techniques are more appropriate for assessing near-term economic prospects.

25X1

We have used SOVSIM since 1979 to examine Soviet economic issues of the 1980s. Besides developing baseline views of economic prospects, we have also used the model as a scenario analysis tool by altering equations or data assumptions to reflect new policy initiatives or alternative technological developments. This analysis permits us to study questions such as the impact on future economic performance of postulated resource shifts into or out of defense, of possible Western credit constraints, or of alternative Soviet energy production prospects.

25X1

The model also provides other distinct research and analytical benefits:

- It gives a discipline and organization to the central storage of large amounts of data on the Soviet economy that facilitates their retrieval and use.
- Construction and maintenance of its data base and multidisciplinary analysis with the model encourage greater interaction among analysts than would probably occur otherwise.
- Its use as an analytical tool forces assumptions to be made explicit so that they can be examined and debated.
- The analytical product flowing from the model has much greater internal consistency than would be possible using alternative approaches

The model consists of over 400 equations, each describing a particular facet of the Soviet economy. Some are merely definitional; others express behavioral and technological relationships among elements of the economy. The specific form of each behavioral and technological equation is periodically estimated econometrically from relevant historical data. Projections based on such equations assume that the historical relationship is not likely to change significantly in the period to be projected.

25X1

25X1

SOVSIM groups the individual equations according to the main components of the Soviet economy. *Resource inputs* are described by equations detailing the availability and use of labor and the flow of investment goods

25X1

into the capital stock. Still others lay out energy production and demand to allow for possible shortages that could constrain the use of capital stock 25X1

The *producing sectors* are described by another group of equations. Industrial production is disaggregated into specific sectors, such as machine building and industrial materials. Output of oil, gas, coal, and electricity is treated separately. Agricultural production is disaggregated into grain, nongrain crops, and livestock products. Output of specific services, such as construction, transportation, and trade, is also considered.

25X1

Foreign trade and finance are treated by other equations. These account for trade with Eastern Europe, the West, and the Third World and describe financial transactions with hard currency countries that determine the Soviet hard currency payments and debt positio 25X1

Finally, the *uses of output* are described through a set of equations that represent the national economic accounts. These pull together all of the production and trade results and describe the uses to which the goods and services available to the economy are put: consumption, investment in either new plant and machinery or repairs to existing production facilities, defense, and exports to pay for imports or to reduce foreign debt. 25X1

Most of the equations in the model are linked. The results obtained, therefore, are more comprehensive and internally consistent than those that would be obtained by analysis of individual sectors of the economy, and they include both the direct and indirect effects of events affecting the economy. This makes SOVSIM especially useful for studying how one aspect of the economy, say energy development, might affect another, such as the hard currency payments position. Such links allow errors in the description of one sector to be transmitted to related sectors and therefore must be handled with care; however, they reflect the interrelationships that actually exist among the various components of the Soviet economy. 25X1

SOVSIM also captures dynamic relationships operating in the Soviet economy by linking the flows of resources, outputs, and other economic values over a number of years. For example:

- The active capital stock in any year depends on investment in machinery and energy made in previous years.
- The hard currency debt at any time is a function of past borrowing and repayments.

25X1

These dynamic relationships facilitate examination of the growth prospects of the Soviet economy and the long-run consequences of events and policies. The calculations for each individual year in turn provide a snapshot of the economy's future size and structure.

25X1

The limitations of such models should not be ignored. Results can be no better than the quality of the underlying structure and data. If little institutional, technological, or political change is expected in the economy, a model based strictly on historical economic experience may yield sufficiently good results. If change is expected, however, the structure of the model and the required data inputs must be adjusted to reflect where the economy is going, not where it has been. Only then will it yield projections that can serve as useful descriptions of possible future courses for the economy.

25X1

SOVSIM can be evaluated in several different ways, including *ex post* and *ex ante* projections of historical periods and comparison with other models. The model well describes *ex post* the trend of a number of Soviet economic activities over the 1975-83 period. Estimates of annual GNP (in 1970 rubles) average less than 0.5 percent below actual values. Corresponding average errors in estimates of yearly output in various industrial, agricultural, and service sectors and annual consumption and investment are no more than 3 percent. Errors for the trade sector are greater, with grain import estimates averaging 6 percent below and balance-of-payments measures averaging up to 11 percent above actual values for 1975-83. (

25X1

The record of *ex ante* projections of Soviet economic growth for the 1981-84 period is varied because of the wide fluctuations in actual Soviet performance. Specifically, projections of average industrial growth rates for 1983-85, based in part on the poor record of the preceding three years, turned out to be too low. On the other hand, projections of average agricultural growth have improved in recent years as actual performance moved back toward trend levels. Projections of average consumption growth rates have been consistent, if on the low side, while those for average investment growth have varied more widely; the most recent projection is close to the actual average. In recognition of these differences between past model projections and actual values, present analysis of economic growth is conditioned on a variety of alternative scenarios. This approach yields a better appreciation of the range of possible outcomes and their implications for the economy.

25X1

25X1

SOVSIM projections can be compared with those made by other models of the Soviet economy. Projections made with SOVMOD, the most important of these models, are more optimistic—largely because of more favorable assumptions regarding productivity, investment, and agricultural and energy output. SOVMOD, for example, has assumed that the higher labor and capital productivities of the late 1960s and early 1970s reflect likely trends for the rest of the 1980s. SOVSIM projections, on the other hand, assume that these higher productivities represent the upper end of a range of likely levels. The track records for both models are equally mixed. Differences between the two models are not necessarily bad, however, for they sharpen the debate about the performance of the Soviet economy and help to suggest limits to development possibilities

25X1

Contents

Tables

25X1

Modeling the Soviet Economy: SOVSIM After Six Years

25X1

SOVSIM: A Description of the Soviet Economy

The Soviet economy is the second largest in the world—some 150 million persons working at hundreds of thousands of locations to produce annually over 20 million different goods and services worth almost $2 trillion. SOVSIM describes only the most important general features of this economy. It groups all Soviet economic activities into 15 major producing sectors, treating the output of each as a "single good," and then allocates this output to four major uses—consumption, investment in future growth, defense, and exports (inset)

Resource Inputs

For most sectors of the economy, output is estimated from the labor and capital available in the sector by a "production function," an equation that describes the relationship between the quantities of these inputs required to produce a unit of output. Production may be reduced, however, by energy shortages

Labor. The size of the Soviet labor force is derived from population and labor growth estimates prepared by the Center for International Research of the US Bureau of the Census (figure 2). Projections of military manpower, provided by CIA military analysts, allow the model to estimate the civilian labor force. Deduction of agricultural employment from Census projections then yields the nonagricultural work force. Annual increases in nonagricultural employment are allocated to each relevant sector on the basis of the marginal investment share and the marginal capital-labor ratio believed to hold in that sector.

Capital. The Soviet machine-building and construction sectors are the sources of the stock of plant and equipment that are used to produce goods and services for the entire economy (figure 3). Some of their output is devoted to military needs. Some is sold to consumers as durable goods. Some machinery is also exported, although these exports are more than balanced by imports of equipment from other countries. What remains is used for investment in the Soviet economy.

SOVSIM: Overall Structure

Producing Sectors
Industry
- *Machinery*
- *Chemicals*
- *Ferrous metals*
- *Nonferrous metals*
- *Construction materials*
- *Forest products*
- *Consumer goods*

Energy
- *Coal*
- *Gas*
- *Petroleum*
- *Electric power*

Agriculture
Construction
Transportation and communications
Trade and services

Uses of Output
Consumption
Investment in future growth
Defense
Exports

25X1

25X1

25X1

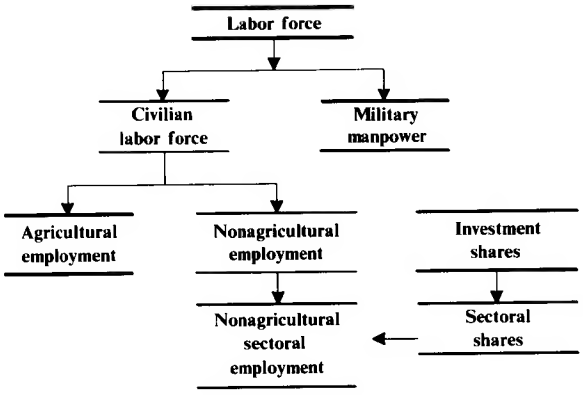
Some investment is used to repair machinery and facilities, and some replaces equipment that is being retired because of old age. Most investment, however, is used to augment the stock of productive machinery and buildings and hence to increase its ability to produce goods and services in the future.

25X1

25X1

Estimates of military procurement and construction, machinery imports, and output of durable consumer

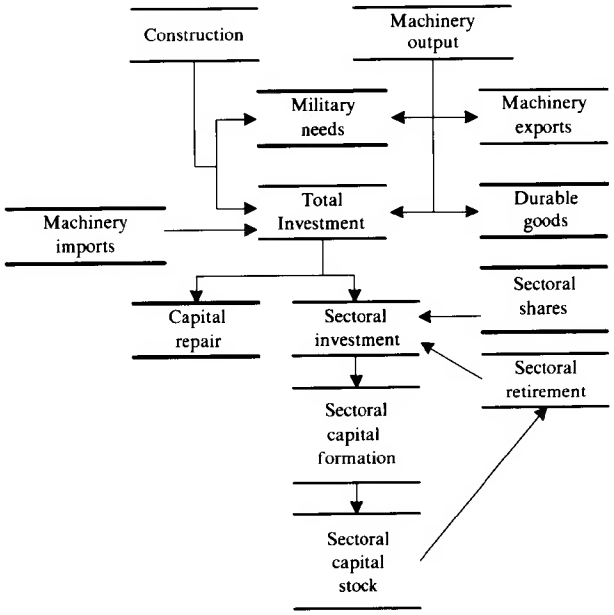
Figure 2
SOVSIM: Labor Sector Flowchart[a]



[a] Variables in bold boxes are inputs to the model. Other variables are computed by the model.

305059 7-58

Figure 3
SOVSIM: Capital Sector Flowchart[a]



[a] Variables in bold boxes are inputs to the model. Other variables are computed by the model.

25X1

goods are made by CIA analysts. Estimates of machinery exports have averaged about 6 percent of final sales of machinery in recent years. These estimates are subtracted from the value of machinery and construction output, as computed in the model's industrial production block, to arrive at investment. This is then allocated among the sectors of the economy in the model on the basis of recent trends, the latest annual or five-year plan, or the expected relative priorities of investing in the different sectors. Scenarios may involve various allocations, each representing a different set of priorities, to uncover the economic potential and possible bottlenecks inherent in the Soviet economy. It is also possible to turn the model around to examine instead the consequences of alternative-assumed investment growth rates on defense procurement or consumer durable production.

Energy in the Production Process. Relative energy availability in a given sector may affect output in that sector. If energy shortages occur, resources are not fully utilized and output is reduced. For this reason, the determination of an overall energy balance and the distribution of energy to productive sectors, consumers, and the export market are critical factor

25X1

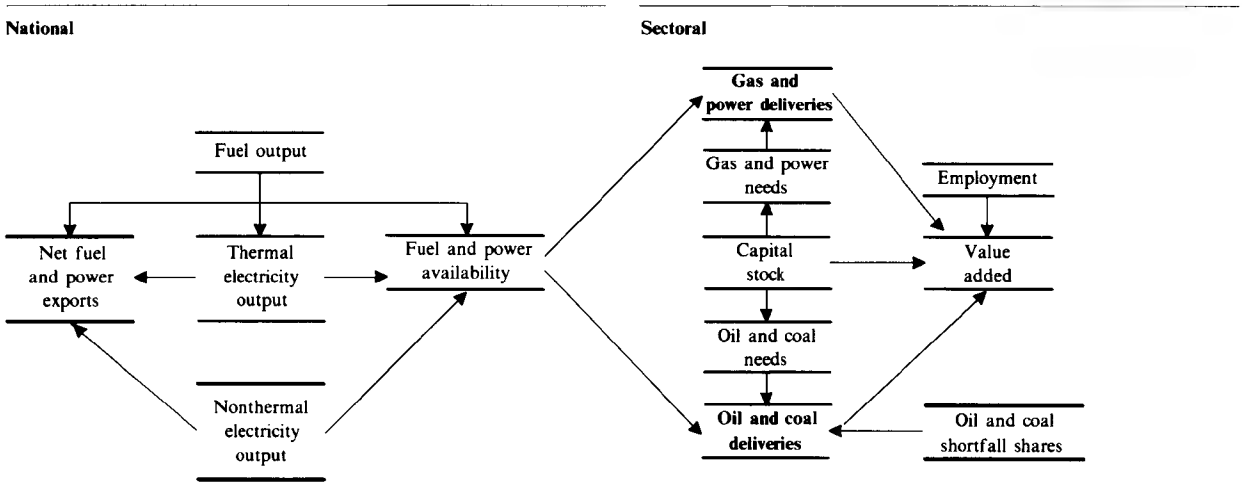
25X1

Projections of energy exports, based on both domestic needs and likely trade policies, are supplied to SOVSIM by CIA energy analysts (figure 4). From these and computed production of energy, SOVSIM calculates the availability of energy to domestic users. CIA analysts also estimate the energy needs of the various sectors of the Soviet economy as well as the domestic distribution of available energy. This information suggests the relative satisfaction of sectoral needs

25X1

25X1

Figure 4
SOVSIM: Sectoral Fuel Deliveries and Value Added Impact[a]



[a] Variables in bold boxes are inputs to the model. Other variables are computed by the model.

25X1

Because current projections reveal no indication of electricity or gas shortages, SOVSIM assumes that availability of these energy sources meets requirements and equates their use to total production less net exports.[1] Evidence does indicate the possibility of oil and coal shortfalls through 1995. The model allows for the possibility of such shortages and rationing among the various economic sectors.

The Production Process

SOVSIM groups economic output into 15 different sectors. For each, output is measured as the total value added by the sector to the products and service it produces.[2] In addition, physical output is estimated for the energy sectors, grain, and meat.

[1] There have been sporadic electric power outages because of weather conditions, fuel transport bottlenecks, and other transitory phenomena. There is, however, no shortage of electric power capacity, and more capacity is expected to be installed over the period that is to be analyzed with SOVSIM.

[2] Value added is the difference between the value of the sectoral output and that of its material and energy inputs. It constitutes the *value added* to these raw materials by the capital and labor used in the sector to produce output.

Agriculture. SOVSIM models Soviet grain, nongrain crops, and livestock production separately (figure 5). Grain production is especially important:

- As a direct source of food for the Soviet consumer.
- As feedgrain that, along with available roughages and nongrain concentrates, determines the growth of livestock herds and hence the output of meat and other livestock products.

25X1

Soviet leaders generally rely on grain imports to make up for shortfalls in domestic supply, but such imports require hard currency payments. A good grain harvest, therefore, not only facilitates food production, which raises consumer well-being, but also eases the demand for hard currency.

25X1

25X1

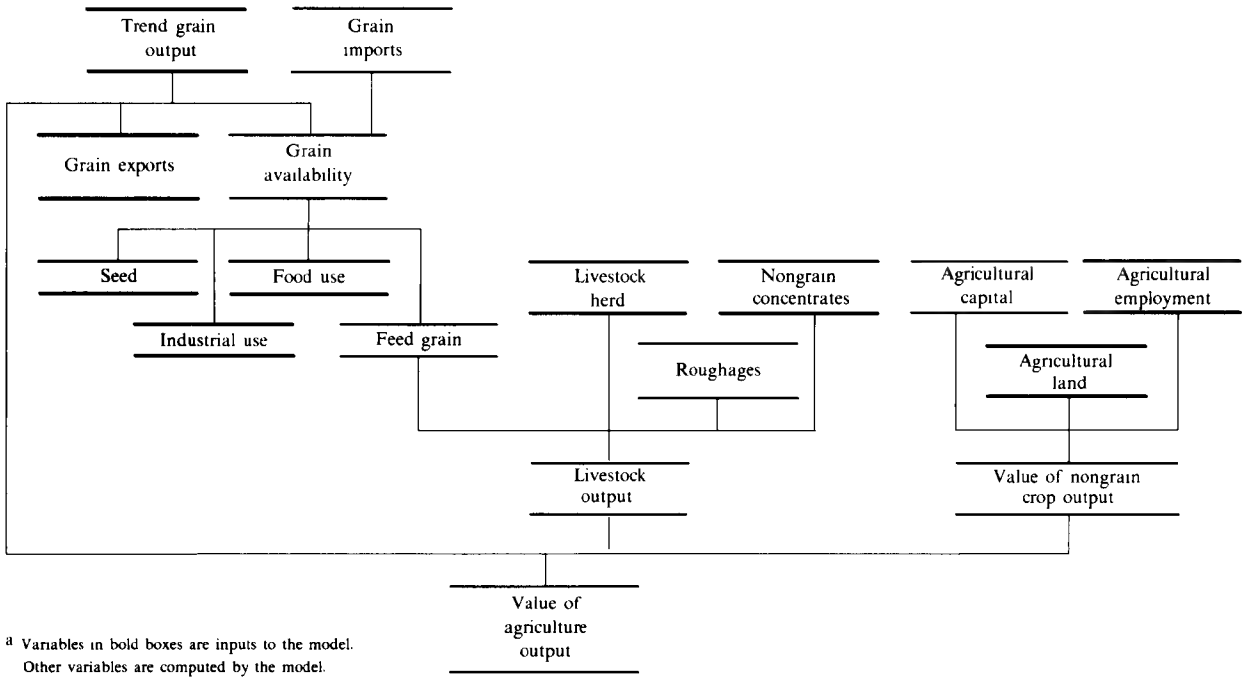
In SOVSIM, Soviet grain output is projected by trend grain production as estimated by CIA analysts.[3] Grain

25X1

25X1

25X1

Figure 5
SOVSIM: Agriculture Sector Flowchart[a]



[a] Variables in bold boxes are inputs to the model. Other variables are computed by the model.

306062

25X1

imports are projected by the model from an historically derived equation relating imports to domestic production and poultry stocks. CIA analysts also project nonfeedgrain uses on the basis of expected supply and demand. Feedgrain availability is estimated as a residual. Over the long run, changes in grain stocks are assumed to be small on averag

Meat output is computed separately for beef, pork, and poultry from the historical relationship between these commodities and feed supplies, livestock herd size, and changes in the herd size. Estimates of other meat products are provided by CIA agricultural analysts. SOVSIM projects nongrain crop output from the historical relationship between such output and agricultural capital and employment and land sown to nongrain cro

Expected prices for grain and meat products are used to arrive at an estimate of the total value of grain and meat production, respectively. The value of total agricultural output is computed by adding these to the value of nongrain crop output. Deducting the estimated value of agricultural purchases from other sectors of the economy yields agricultural value adde

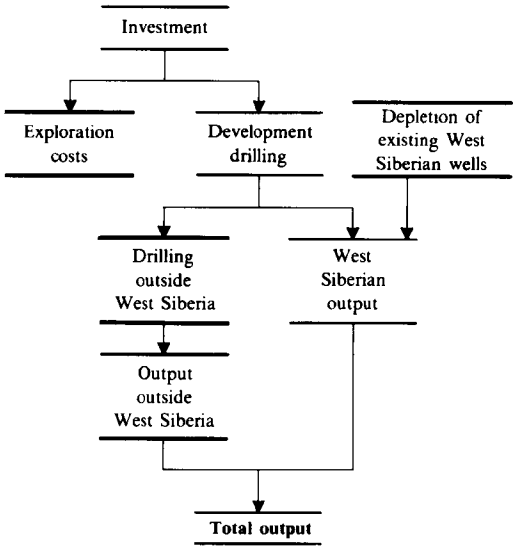
25X1

25X1

Energy. Oil output is by far the most important product of the energy sector. It declined slightly in 1984 and may well continue to decline over the next decade, creating the possibility of energy shortages. The Soviets themselves are aware of this danger. They are expanding gas production as rapidly as possible,

25X1

Figure 6
SOVSIM: Oil Output Flowchart[a]



[a] Variables in bold boxes are inputs to the model. Other variables are computed by the model.

but gas cannot easily replace oil in many uses. The Soviets are also investing even more heavily in the oil sector to try to sustain output. Maintaining oil production, however, is becoming increasingly difficult, as output in the large fields of western Siberia begins to taper off. Moreover, no other readily accessible large fields are being developed. The cost of developing new production, therefore, is increasing and placing a considerable strain on Soviet investment allocation.

The importance of oil production in the Soviet economy is mirrored in SOVSIM by a detailed description of that sector. Overall exploration needs, as estimated by CIA analysts, determine the investment available for development drilling (figure 6). The drilling that occurs in western Siberia fixes the number of new wells in the region and their flow rate. Along with depletion of resources at existing wells, these then determine total output in western Siberia. Oil output in other regions is estimated by CIA energy analysts.

25X1

Output of other fuels and power is determined by investment and labor inputs in these sectors. Energy production is converted to value added in 1970 rubles according to the output-value-added ratio for that year.

25X1

Industrial Production and Services. Other Soviet production originates in a number of industrial and service sectors (first inset). The industrial sectors include machine building, ferrous metallurgy, nonferrous metallurgy, construction materials, forest products, consumer goods, and chemicals. The main service sectors are construction, transportation and communications, and trade and services.

25X1

SOVSIM estimates the output of each of these sectors by means of a production function, an equation relating the annual capital and labor available and the output produced in a given sector. The exact form of the function used for each sector is estimated by examining the historical relationship between labor and capital availability and output in that sector

25X1

Projections based on such functions are valid to the extent that the historical conditions underlying past production in the sector continue to hold during the projection period. In fact, these conditions will change, but they may not shift radically over the next 10 years:

25X1

- The Soviets seem reluctant to scrap existing equipment; even if new technology were to appear in a given sector, it would take a long time for the more productive equipment to make up enough of a share of total capital in the sector to alter average productive performance significantly.

25X1

- Given the educational and training systems used by the Soviets, the quality of labor is also unlikely to improve rapidly.

- Nor are Soviet administrative and management practices likely to change sharply.

- Other changes, such as those in weather conditions, may occur but are as likely to retard, as they are to improve, productive performance.

On balance, then, the net effect on the conditions underlying productive performance in the various sectors is not likely to change very much over the next five to 10 years

25X1

Where a significant departure from past conditions is expected, the parameters of the equation in question may be altered on the basis of the analyst's judgment to reflect the new situation. Where uncertainty exists as to which of alternative possibilities may hold, alternative sets of parameters, each reflecting one of the possible situations, may be used to arrive at the range of possible outcomes. The latest projection of the Soviet economy uses this approach because of uncertainty as to the future productivity of Soviet capital and labo

25X1

Using the production function in output projections allows us to estimate the contribution of both capital and labor to output in each sector and hence the impact of changes in capital and labor on sectoral output. We can also examine the consequences of separate changes in capital and labor efficiency and technological change on sector output. Because these areas are critical to the development of the Soviet economy, SOVSIM's production functions provide a tool for exploring questions that concern the Soviet leadership

25X1

International Economic Relationships

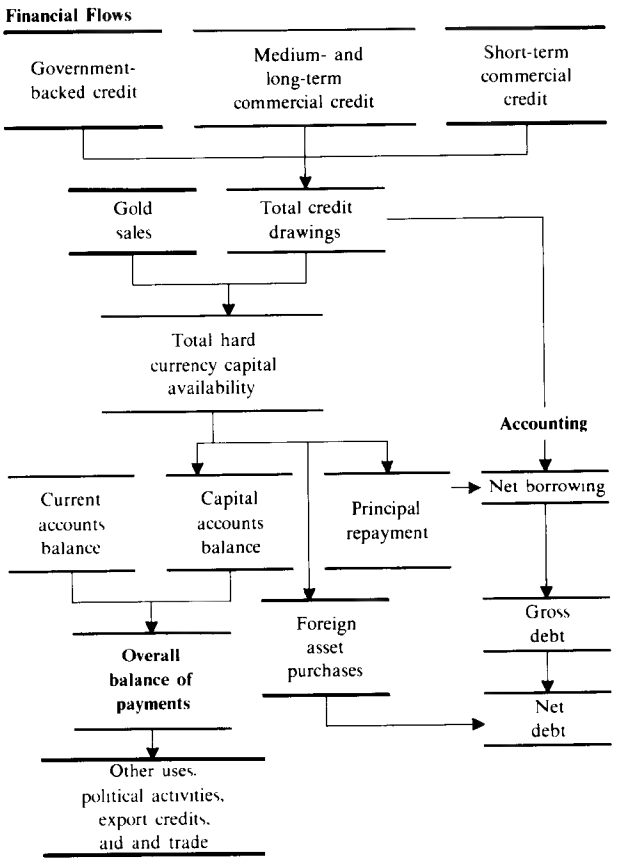
Hard currency imports have been particularly significant in several key sectors of the Soviet economy:

- Grain purchases have helped to ease the consequences of poor harvests and permitted expansion of Soviet livestock herds and meat production.
- Machinery imports, while small compared to total Soviet investment, have been important to the expansion of energy and chemicals production and transportation services.

Hard currency imports are projected by CIA trade analysts. In the model, they can also be set as a policy variable to determine their impact on the balance-of-payments position and the rest of the economy.

25X1

Figure 7
SOVSIM: Overall Hard Currency Balance of Payment Flowchart[a]

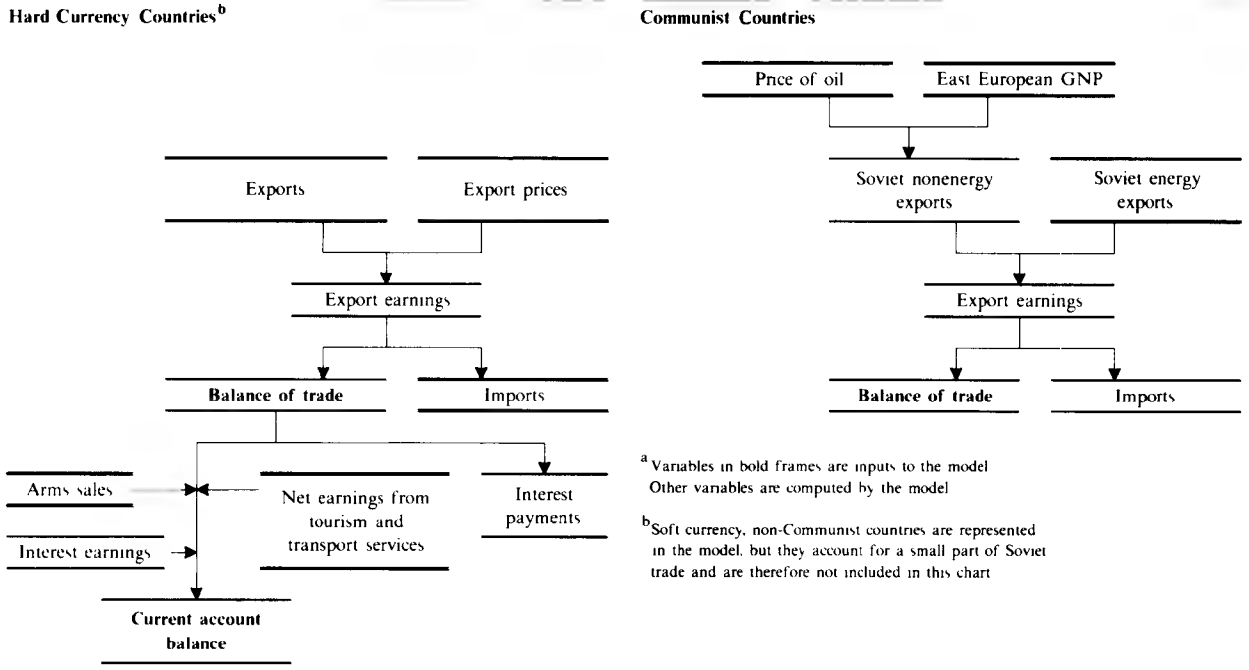


[a] Variables in bold frames are inputs to the model. Other variables are computed by the model.

306064 7 85

The USSR's ability to pay for these imports depends on the hard currency it receives from exports, gold sales, credit drawings, and interest earnings on and the sale of foreign asset holdings (figure 7). These receipts are projected by CIA analysts. The analysts also project government-backed and short-term commercial credit drawings. Given projected import needs, medium- and long-term credit drawings required to clear accounts are computed by SOVSIM.

Figure 8
SOVSIM: Trade and Current Account Balance[a]



[a] Variables in bold frames are inputs to the model. Other variables are computed by the model.

[b] Soft currency, non-Communist countries are represented in the model, but they account for a small part of Soviet trade and are therefore not included in this chart.

305065 7 85

25X1

The model also computes various statistics describing the Soviet hard currency position, including the hard currency current and capital account balances, debt, debt service, and the debt service ratio. Alternatively, SOVSIM can solve for hard currency import capacity on the basis of projected credit drawings, or, given constraints on the debt service ratio, the model can compute the level of one or more import components.

SOVSIM assumes that intra-CEMA trade is handled largely on a barter basis. Nonenergy exports to the Communist Bloc depend on East European economic growth and the price of oil charged to Communist countries, as indicators of need and ability to pay, respectively (figure 8). In turn, Soviet imports from Communist countries depend on total Soviet exports to those countries. Both of these relationships are estimated from historical data.

Users of Goods and Services in the Soviet Economy

Each sector of the Soviet economy requires inputs from other sectors. If these inputs are subtracted from the gross output of the sector, the remainder measures the value added, the new output, produced by that sector. In SOVSIM the output of all sectors except agriculture is computed directly as value added. Agricultural value added is obtained by subtracting the value of inputs from gross output. Military value added is obtained as military wages, projections of which are obtained from SOVA military analysts

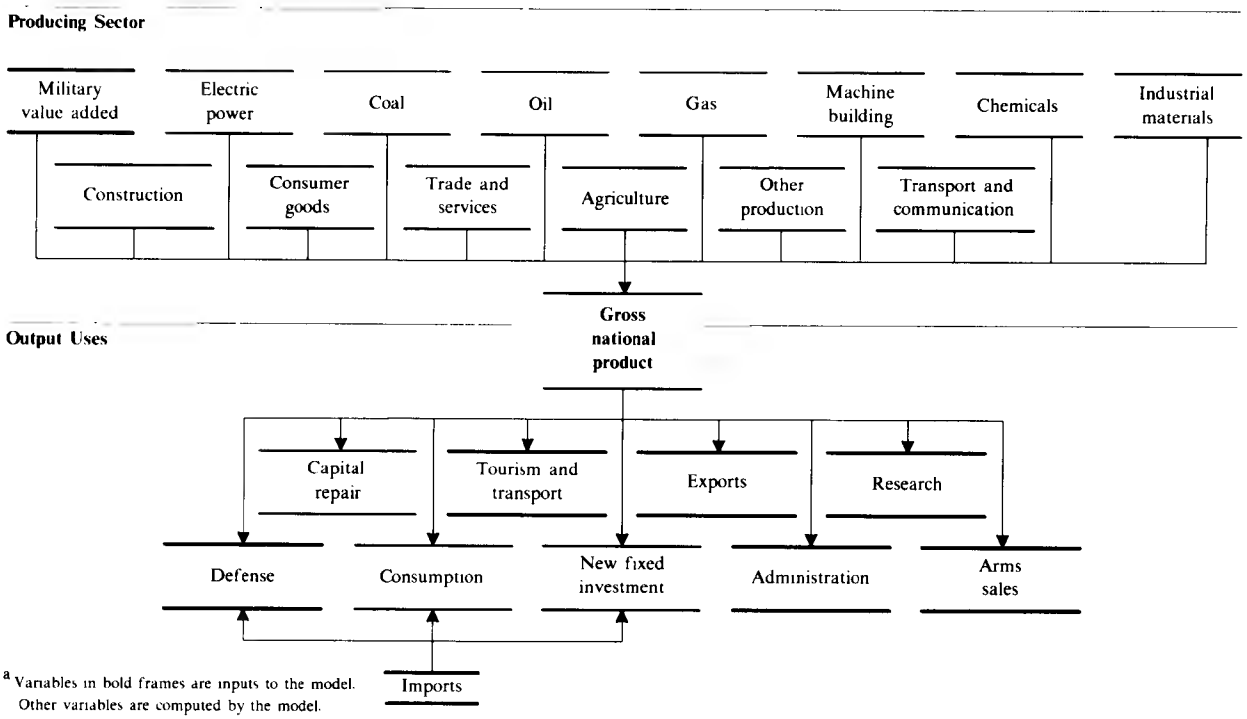
25X1

The total value added by all sectors is the gross national product of the economy. Some of this output is used to repair or replace equipment and facilities. What remains is the net national product (NNP) of

25X1

25X1

Figure 9
SOVSIM: National Income Accounts Flowchart [a]



[a] Variables in bold frames are inputs to the model. Other variables are computed by the model.

306066 7-85

25X1

the economy.[4] Some of the NNP is sold or traded to other countries. In return, the Soviet Union receives other goods and services, some of which are used as inputs in Soviet production. The remainder and the NNP that is not traded away are available to the Soviet economy for final use:

- Consumption.
- Investment.
- Government activities, including defense, research and development, and administratio

[4] The Soviets structure their national income accounts differently. The definitions in SOVSIM are those of the Western market economies and are used to facilitate a better understanding of Soviet economic activities and comparison of these activities to those in the West

Government activities are projected by CIA analysts. Investment may be either specified to determine its impact on consumption and other variables, or projected by the model as the output of the machine-building and construction sectors—adjusted for defense procurement and construction, production of consumer durables, net exports of machinery and equipment, and capital repairs

25X1

Consumption is computed as a residual (figure 9), after other final uses are subtracted from the goods and services available for final domestic use. It is adjusted by an estimate of the additional value gained by the export of gold and energy products. Since the mid-1970s, rising world prices for these exports have

25X1

25X1

25X1

increased their value far above the factor costs of production, causing Soviet hard currency earnings to soar. The result has been a growth in Soviet hard currency imports that has benefited both investment and consumption.

25X1

Data Requirements

SOVSIM simulates the economy one year at a time. For each year, estimates for each output variable in the model are computed from model relationships and available data. Some of these data may have been computed by the model as results for preceding years or for other equations. Other required data are not computed by the model at all but must be supplied to it for each year of the projection. Several different types of data are needed:

- The estimated parameters of those relationships that are derived econometrically from historical observations. The model assumes that the underlying Soviet behavior and technical relationships will not change during the projection period.
- The most recent historical values of those variables that the model is to project over time; these are a starting point for model calculations.
- Projections of values of those variables that may change over time but are not computed by the model—policies, technological conditions, economic conditions in other countries, natural phenomena; these are needed for each of the years to be simulated and are obtained from experts and other outside sources.

Equation parameters, the first type of data, are estimated periodically by straightforward, well-known statistical techniques. Their values involve some degree of uncertainty because of the quality of the underlying data and limitations inherent in the statistical estimation procedure. Nevertheless, these data are believed to be relatively accurate. Initial conditions for the model, the second type of data, are also reasonably accurate, given the quality of historical data available on the Soviet economy.

Major Data Requirements

Sector/Item
Agriculture
- *Grain output*
- *Livestock herd*

Energy
- *Trade*
- *Distribution priorities*
- *Sectoral energy/output rates*
- *Expected production*
- *Expected investment*

Investment distribution
Population
- *Age-sex population levels*
- *Sectoral employment rates*
- *Sectoral labor distribution*

Trade and international
- *Gold sales*
- *Arms sales*
- *Foreign assets*
- *Imports and exports*
- *Government and pipeline credit drawings*

Defense
- *Procurement*
- *Construction*
- *Pay rates*

Other
- *Research and development*
- *Government administrative expenses*

25X1

Estimating the future course of the other variables found in the model is a large and difficult task. Here the SOVSIM effort relies heavily on:

25X1

- Extrapolation of likely trends established by previous analysis.
- The judgment and research findings of other experts on the Soviet economy both within the CIA and at other government and academic and research institutions (inset).

25X1

These projections involve differing degrees of certainty. For example, estimates of labor force growth are relatively firm, because population changes occur slowly over time and participation rates are already so high in the Soviet Union that they are not sensitive to policy shifts. On the other hand, the distribution of GNP among primary uses—consumption, investment, defense, and net exports—although subject to some rigidities, is ultimately subject to policy choices that could change significantly over the period to be simulated

In general, we have more certainty about input values that are subject to little, if any, policy manipulation or are clearly reflections of long-term trends not likely to be quickly reversed. We have less certainty about those values that can be strongly influenced by such factors as policy decisions and international market forces. Where the uncertainties are greatest, we may try alternative projections to gauge the sensitivity of the model's results. Furthermore, where gaps in our knowledge of the Soviet economy exist, SOVSIM provides a means of estimating unknown values by showing the range over which they would be consistent with what *is* known of Soviet economic activities.

Thus, SOVSIM brings together a diverse body of information and provides a means of checking the consistency of data obtained from a variety of sources. This helps us to assess the value of existing intelligence and research activities and to suggest what additional efforts may be needed

SOVSIM: A Tool With Many Uses

SOVSIM's output is a quantitative description of the domestic and international sectors of the Soviet economy (table 1). The model can be used in various ways to study and help answer different questions about the economy:

- How well has the economy performed over the recent past?
- How well is it now operating? What problems does it face and how might they be solved?
- Under the conditions that will probably prevail, how is the economy likely to develop over the next three to 10 years?
- How might this projection change if one or more of the assumed natural conditions or policies is changed?
- What requirements are needed to carry out specific Soviet policies or reach given goals

25X1

Analysis of Historical and Current Developments

Although we already know a great deal about Soviet economic activities since the mid-1970s, SOVSIM can be used to help us understand why certain developments occurred and what impact they had on the economy. For example, the model can be used to examine the decline in the rate of growth of Soviet GNP during the past decade, from 3.7 percent per year during the 1971-75 period to 2.5 percent per year in 1976-82. While the causes for this decline are shrouded in some uncertainty,[5] analysis with SOVSIM may be able to suggest some of the factors that could be involved

25X1

25X1

Sharp reductions in the rates of growth of oil output and the labor force also took place during the past 10 years, that for oil falling from 6.9 percent a year during the first period to 2.9 percent in the second and that for labor from 1.6 percent a year from 1970 to 1975 to 1.1 percent during 1980-82. If Soviet oil output had continued to grow at the earlier rate (all other things, particularly oil industry investment, remaining equal), GNP would have grown almost 0.3 percentage points per year faster after 1975 than it actually did and would have been almost 2 percent greater in 1982 than it was.[6] If the labor force had continued to grow at the 1971-75 rate, GNP growth would have been about 0.25 percentage points per year faster after 1975, and 1982 GNP would have

25X1

25X1

[6] This estimate is conservative. SOVSIM results indicate that at the higher rate of growth of oil production, oil supplies would have exceeded the economy's direct needs and resulted in a considerable surplus. In the oil-short world of the late 1970s, this surplus could have been exported for hard currency to finance the purchase of investment goods that could have supported additional growth of the econom

25X1

Table 1
Types of Model Output

Sector/Item	Output	Investment	Employment	Capital Stock	Fuel Requirements
Agriculture	VA	V	Q	V	Q
Grain	Q				
Meat	VA/Q				
Nongrain crops	VA				
Energy	VA/Q	V	Q	V	Q
Coal	VA/Q	V	Q	V	Q
Gas	VA/Q	V	Q	V	Q
Electricity	VA/Q	V	Q	V	Q
Oil	VA/Q	V	Q	V	Q
Industry					
Machinery	VA	V	Q	V	Q
Chemical	VA	V	Q	V	Q
Ferrous metals	VA	V	Q	V	Q
Nonferrous metals	VA				
Construction materials	VA				
Forest products	VA				
Consumer goods	VA	V	Q	V	Q
Services					
Construction	VA	V	Q	V	Q
Transportation and communications	VA	V	Q	V	Q
Trade and services	VA	V	Q	V	Q
Housing (construction)		V		V	Q
Capital repair		V			
Aggregate consumption	V				

Foreign trade	Hard Currency	Communist	Soft Currency
Current account balance	V	V	V
Balance of trade	V	V	V
Exports	V	V	
Imports	V	V	
Interest	V		
Gold sales	V		
Capital account balance	V		
Credit drawings	V		
Repayments	V		
Debt	V		
Debt service ratio	Q		

Q — quantity
V — value
VA — value added

25X1

been about 1.6 percent greater. It appears that these two factors alone could explain almost half of the decline in the GNP growth rate since 1975. If so, however, other factors must also have contributed to the decline in GNP growth.

SOVSIM is also useful for evaluating current Soviet economic developments and problems. One area of interest is the rate of growth of the industrial sector of the economy that, until 1983, had been declining quite steadily since the 1950s. Since the mid-1970s this decline has been exacerbated by a decline in the rate of growth of capital and labor productivity. Analysis with SOVSIM reveals that, if Soviet industry were making as efficient use of capital and labor today as it did in the early 1970s, industrial output would be growing about 50 percent faster than it did during the early 1980s

Projections of the Soviet Economy and Scenario Analyses

Since 1979 SOVSIM has been used extensively to provide a complete, integrated view of Soviet economic prospects. Research papers in 1979, 1982, and 1984 presented full baseline projections of the Soviet economy in the 1980s.[7] SOVSIM has also been used to explore the consequences of changes in the energy, agricultural, and trade sectors; the structure of investment; productivity levels; and end-use orientations of the Soviet economy—either because of policy shifts or other conditions. The model has been useful in evaluating the potential impact on the Soviet economy of Western policy options such as embargoes of grain or energy equipment and credit restrictions

Such studies allow us to evaluate the impact of different policies on various economic outcomes and thus provide a better understanding of the economy's inherent potential and the barriers and bottlenecks that may appear under different circumstances. For example, a 1982 study [8] suggested that significant reductions in defense spending during the 1980s could allow Soviet GNP growth to increase and would probably enhance the availability of consumer goods in the economy. In the important agricultural sector, Soviet grain output has recently deviated significantly from trend levels, with production averaging 8 percent below trend from 1979 through 1982 and 16 percent above from 1976 through 1978. A 1984 SOVSIM analysis [9] suggests that, given Kremlin goals related to consumption, such deviations could seriously affect the hard currency balance-of-payments position and, depending on the reaction of Soviet leaders, indebtedness to Western countries or merchandise imports from the West.

SOVSIM can also be used to determine the resources and activities needed to achieve specific economic goals or to carry out certain policies. Such analyses reveal the feasibility of these goals and policies and the obstacles that may impede their achievement and execution. They indicate what they will cost the Soviet Union and provide a means of comparing the costs of alternatives to arrive at an estimate of the relevant trade-offs.

Limitations

SOVSIM is subject to various limitations. Some of these apply to all economic models; others are unique to SOVSIM. Any economic model contains only those features that the user feels are important. Therefore, it cannot be used to explore problems involving other components of the economy. Moreover, because each model is generally structured to perform a particular task—such as simulating activities, finding optimal solutions, or determining operational levels of activities—it can be used to perform other tasks only poorly or not at all. Finally, the validity of results from any model depends on the quality of its construction and supporting data base. A model that does not describe reality well or that uses inaccurate data is unlikely to yield good results.

25X1
25X1
25X1
25X1
25X1
25X1
25X1
25X1

As with any tool, SOVSIM is suited to certain jobs but not to others. Because it is a simplified description of the Soviet economy, the model lacks the interrelationships and complexity needed to deal with many interesting problems. For example, SOVSIM:

- Does not embody a full input-output table. Therefore, it can address "balance" issues only in selected areas—energy, construction, agriculture (grain), and machine building. Nor can it ensure that each producing sector receives all of the different kinds of intermediate products that it requires. Therefore, it cannot deal with specific bottlenecks.

- Reflects a particular structure of the Soviet economy and is not applicable to projections of situations involving significant changes in that structure.

- Is not meant to arrive directly at optimal answers to problems. Other models exist for such analyses.

- Is not suitable for examining short-run problems. It lacks many of the variables that determine short-run variations in Soviet economic activities. Moreover, the model's structure has been estimated from long-run trends and is geared to the study of longer run developments.

SOVSIM does not make predictions; rather it projects trends based on specific assumptions and the data used. Each projection involves some degree of uncertainty:

- The estimated structure of the Soviet economy that is made from historical data involves some statistical imprecision.
- It is impossible to foresee technical developments with certainty.
- It is also impossible to ascertain in advance the policies to be implemented by the Soviet leadership.

The uncertainty is greater in some areas than in others. Therefore, model output must be interpreted carefully to take account of the alternative possibilities involved in a particular problem. Often this interpretation requires assessment of a range of possible outcomes rather than a point estimate.

Evaluating SOVSIM

SOVSIM can be evaluated in several different ways. Assessing its ability to describe the Soviet economy is relatively easy: the model can be used to simulate past or present economic activities and the results checked against known historical values. It is more difficult to check SOVSIM's ability to project future economic developments:

- We can examine old projections that were actually made to see how accurate they turned out to be.
- SOVSIM projections can also be compared with those obtained from other analyses.
- Sources of error can be examined by comparing projections based on full historical data with those based partially on data derived in other ways.

25X1

SOVSIM is primarily designed to project medium- to long-run trends. Year-to-year values are strongly affected by changes in weather, international political and economic conditions, and national policies that are not included in the model. We expect, therefore, that SOVSIM will be more accurate in projecting trends and average behavior over a number of years.

25X1

Historical Tracking

25X1

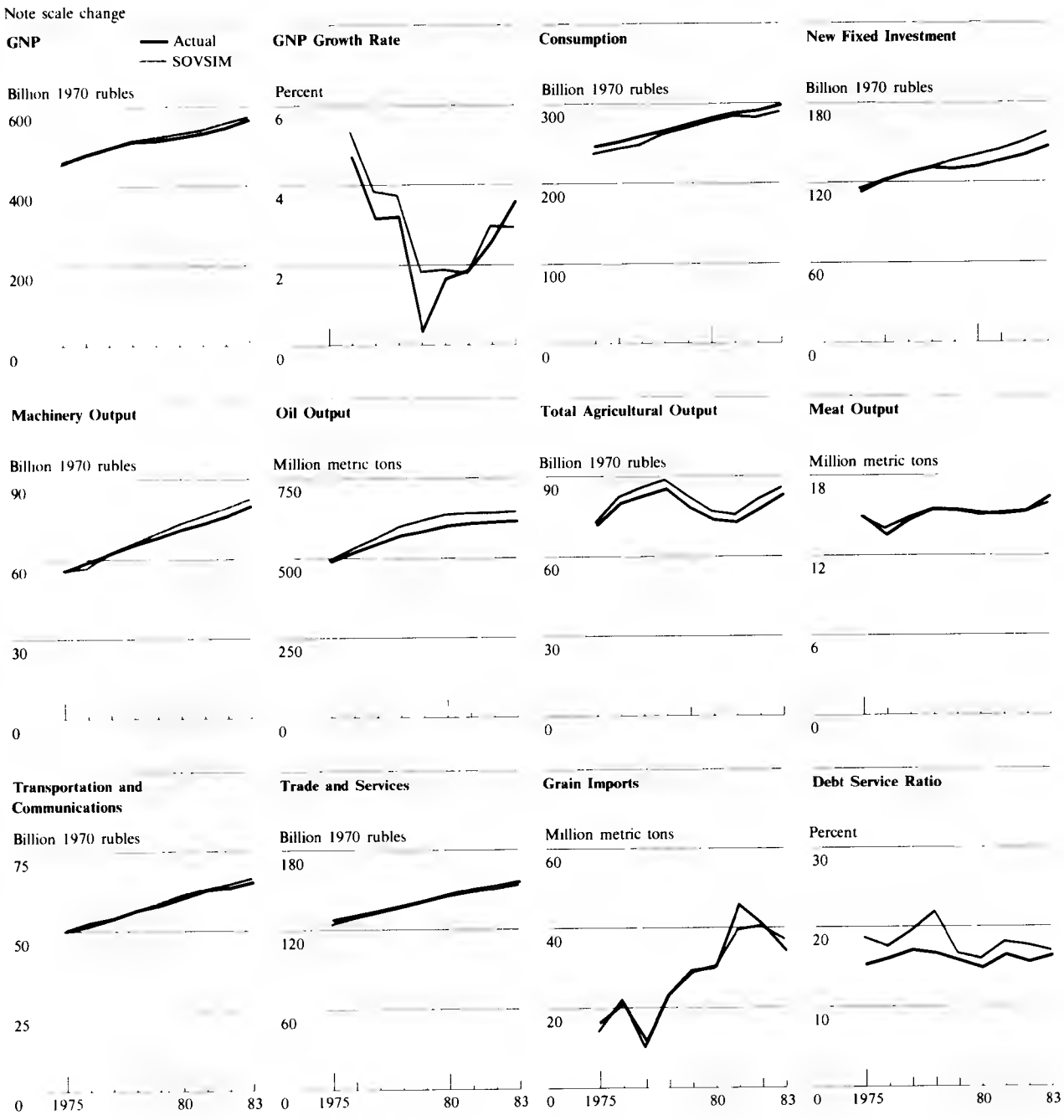
To test the ability of the model to describe the Soviet economy, SOVSIM was used to simulate its activities during the 1975-83 period. The results (figure 10) suggest that SOVSIM can approximate recent and current aggregate economic trends, although it may deviate from actual performance for specific years or activities. As expected, the long-term trends suggested by SOVSIM output do reflect the historical trends. The model output, however, also appears to follow year-to-year changes in the historical values of these variables reasonably well. In only a few cases do model projections of such short-term changes run counter to what actually happened.

25X1

Most model output nearly matches the corresponding historical values. Significant deviations appear to occur only for certain years for a few variables—such

25X1

Figure 10
Comparison of 1975-83 SOVSIM Output for Key Variables With Corresponding Actual Values



25X1

306067 7-85

as GNP growth rates, grain imports, and the debt service ratio—that are computed as residuals. For these variables, relatively small errors in component values can give rise in some years to relatively large errors in the calculated residuals.

For some variables, SOVSIM appears to yield biased results. Estimates of consumption on the end-use side and trade and services on the sector-of-origin side are consistently biased downward over the entire historical projection. An upward bias appears in the case of oil and agricultural output, the debt service ratio, and, in more recent years, new fixed investment. Such biases suggest the omission of one or more explanatory variables or relationships. Even in these cases, however, SOVSIM captures the long-term trends, and few large deviations from actual values occur.

A good summary of SOVSIM's performance in describing these individual activities over the entire historical period is the average deviation of the annual estimates from the actual values for those years (table 2). As might be expected, estimates for the GNP are more accurate than those for each of the component sources and end uses. Component errors tend to average out at the more aggregate level. Even so, the average error for many sectors—such as output of meat and nongrain crops, equipment, and transportation and communications services—is small, because production in these sectors is measured by statistically derived equations that are, on the whole, relatively accurate.

Results for the international sector are worse. These are generally estimated as residuals of many variables in which the small errors in components carry over as relatively large errors. Therefore, estimates for individual years may be considerably inaccurate, although the model as a whole prevents serious errors from persisting. By contrast, estimates of trade with Communist countries are far more accurate because these are made by statistically derived equations.

An accurate portrayal of past and current developments does not give complete assurance of the model's validity in other uses. It can, however, reveal which segments of the model describe the corresponding components of the Soviet economy reasonably well and which do not. This, in turn, gives us some understanding of the nature and size of the errors that may be involved with specific results and suggests where additional intelligence, research, and modeling efforts must be focused to make the greatest contribution to the performance of the model and the usefulness of its results.

Table 2
Simulation Errors for Key Results, 1975-83

Percent

Result	Average Annual Error	Largest Annual Error
Aggregate		
Gross national product	−0.2 [a]	−2.3 [b]
Total consumption	−3.2	−4.5
Total new fixed investment	2.6	4.3
Sectoral output		
Agriculture	2.4	4.3
Nongrain crop output	0.8	2.2
Meat output	−0.9	4.2
Consumer goods	2.0	3.9
Industrial materials	−3.1	−8.1
Chemicals	2.9	6.4
Construction	2.3	5.5
Machine building	0.6	2.8
Oil output	2.9	4.9
Transportation and communications	−0.9	−3.8
Trade and services	−2.5	−4.0
International trade and finances		
Grain imports	−6.0	−17.5
Hard currency		
Total credit drawings	10.0	32.1
Debt	8.4	10.4
Debt service ratio	11.2	29.6
Communist		
Nonenergy exports	−0.2	−3.8
Nonenergy imports	0.2	−6.9

[a] On the average, over the nine-year period, SOVSIM underestimated actual GNP by 0.2 percent.
[b] The largest error in estimating GNP for each of the nine years was an underestimation of 2.3 percent in 1975.

25X1

Table 3
Comparison of SOVSIM Projections for 1981-85 With Actual Values for 1981-84, Average Annual Growth Rates

Percent

Economic Indicator	Actual for		Projection for 1981-85 Made in			
	1976-80	1981-84	1978	1979	1982	1983
GNP	2.6	2.7	2.7	2.5	2.1	2.4
Sectors of origin						
Industrial output	3.2	3.2	3.6	3.0	2.0	2.3
Agricultural output	0.5	3.2	1.0	0.9	3.8	4.0
End uses						
Consumption	2.7	2.3	2.5	2.1	1.7	2.0
New fixed investment	3.4	2.9	2.6	2.4	1.1	3.2

25X1

How Well Has SOVSIM Performed?

The ability to track historical events may not be a good indicator of how well future events can be projected. One way to assess projection performance is to review past projections of now historical periods. As SOVSIM was developed, projections of Soviet economic activities during the 1981-85 period were made in mid-1978 and mid-1979 and again in 1982 and 1983.[10] A comparison of the results of these analyses with the corresponding historical values (in this case data are available for the 1981-84 period only—table 3) may provide insights into the strengths and weaknesses of the model and suggest ways in which it can be improved.

Initial projections of the 1981-85 average annual growth rate of industrial production were quite close to the actual rate. Those made in the early 1980s, however, were relatively low. This deterioration in projection accuracy might be associated with possible overestimates of the decline in the productivity of industrial capital and labor inputs or underestimates of the ability of the Soviets to conserve use of energy while maintaining industrial production. Current analysis with SOVSIM explores a range of possible productivity and energy-use levels

25X1

Early projections of 1981-85 growth of agricultural output suggested some improvement over the poor performance of the late 1970s. They did not fully anticipate the strength of the recovery that actually occurred in 1981 and 1982, probably because they were strongly colored by the poor Soviet weather of the last half of the 1970s. When weather conditions improved in 1982, revised climatic assumptions caused projections of agricultural output to shift markedly upward, perhaps overcompensating for the earlier error. Although this portion of the model has been much improved over time, projection of agricultural output remains difficult because of the influence of external factors, such as weather conditions. It may be useful, therefore, to consider the various agricultural policies available to Soviet leaders and to explore the implications of different weather patterns for agricultural output

25X1

25X1

Projections of GNP growth rates for the 1981-85 period tend to average out the errors in the sector-of-origin estimates. On the whole, however, they tend to be somewhat conservative. This suggests that

25X1

SOVSIM is likely to provide better estimates at higher levels of aggregation than for more specific activities. As improvements are made in the estimates and projections for the latter, aggregate variables are likely to improve as well but to a smaller extent.

More recent estimates of 1981-85 consumption growth rates have been slightly pessimistic but relatively consistent. The underestimation appears to have resulted primarily from the relatively low estimates of GNP. Because SOVSIM computes consumption as a residual variable, errors in the estimation of the other variables involved in the computation are also probably important. New approaches to estimating consumption, to defining and estimating currently undefined residuals such as inventory changes, and to estimating the role of exports and imports may well be helpful in improving model estimates of consumption.

Estimates of new fixed investment growth have been more volatile, probably because of their dependence on a number of assumptions that have been subject to change over time. These include projections of defense spending, trade, and energy availability. Here again, improvements in these individual areas may help to improve estimates of investment growth. This variable, however, is greatly influenced by Soviet policies concerning consumer durable production and investment allocation. Its estimation, therefore, would benefit from an exploration of the options open to Soviet leaders.

Comparison With Other Models and Projections

The validity of SOVSIM projections can also be assessed against those made with other economic models. SOVSIM differs from economic models of Western, market-oriented economies that focus on demand to determine levels of production, employment, and prices. In contrast, SOVSIM assumes that Soviet output levels are determined by resource availability and the efficiency of production processes. Demand is relatively unimportant, since taut central planning ensures a perpetual state of excess demand.

There are several other Western models of the Soviet economy. The best known of these, SOVMOD, continues to be more optimistic than SOVSIM in projecting the future of the Soviet economy, primarily because of important differences in the assumptions about resource availabilities, policies, and structure of the Soviet economy (table 4).[11] SOVMOD assumes that:

- A larger share of total output is devoted to investment.

Table 4
SOVSIM and SOVMOD Assumptions and Results, Average Annual Growth Rates, 1985-89

Percent

Area	SOVSIM	SOVMOD
Assumptions		
Grain output	3.42	4.56
Energy		
Output	2.01 to 2.49	2.49
Consumption	2.88 to 3.15	2.16
Exports	−3.15 to −1.34	3.85
Labor force	0.48	0.08
Investment	2.00 to 4.00 [a]	NA
Hard currency trade		
Exports	−3.10 to 1.14	9.75
Imports	5.00	13.85
Results		
GNP	1.89 to 2.73	2.66
Industrial output	2.36 to 3.78	2.78
Agricultural output	1.40 to 1.42	2.89
Consumption	1.81 to 2.21	2.33
Investment	2.00 to 4.00	6.42
Hard currency debt	8.59 to 20.67	10.35

[a] The lower bound for investment growth is obtained when SOVSIM is allowed to solve for the rate of growth. The upper bound was exogenously introduced to determine the implications of more rapid investment growth. With SOVMOD, investment is determined by the model; hence, no assumption is made as to the rate of growth of investment.

[11] Wharton Econometric Forecasting Associates, *Centrally Planned Economies Outlook*, Vol. 5(2), October 1984, pp. 59-67.

- The growth of energy output and use are more favorable.
- Grain output will grow faster.
- Both exports to and imports from the West are assumed to grow more rapidly but in such a way that projections of the overall hard currency balance-of-payments position and debt are more favorable.

Because of these differences, SOVMOD projects both total output and consumption to grow faster than does SOVSIM

Soviet economists use similar models, constructed with the same statistical procedures, to examine their economy.[12] They are forced, however, to use data that Western economists believe to be misleading. Much of their research is published openly, so that we can use their perceptions in conjunction with SOVSIM results.

From time to time, results from the various models of the Soviet economy are compared with those produced by SOVSIM. Similarities reinforce our conclusions about the Soviet economy. Differences, however, are not necessarily bad because they often simply reflect our limited knowledge about the Soviet economy and different theories about its operation. As such, they force us to consider more carefully our assumptions and recheck our calculations.

A Test Projection

Projections require an estimate of the structure of the Soviet economy, as reflected in the equations of the model, and the performance of a variety of variables, as provided by the data inputs. Historical observations are available to facilitate the model's construction and use. The economy's structure, however, may change over time, requiring corresponding changes in the model's structure. Moreover, data inputs for the future period to be simulated must themselves be projected by a variety of means and thus are subject to various degrees of uncertainty

[12] The CIA is now working to reconstruct several such models. These will prove useful in assessing the Soviets' perceptions of their economic prospects

SOVSIM projections, therefore, are subject to both model and data errors. Model error involves inaccuracy in the model's equations as a description of the future structure of the Soviet economy:

- Equations concerning significant economic activities may be omitted from the model.
- An equation describing an activity may be incorrectly specified; it may include an incomplete or incorrect set of explanatory variables.
- An equation may show an incorrect relationship between the activity being explained and one or more of the explanatory variables; the estimated parameters of the equation may be incorrect.

Data error involves inaccuracy in the assumptions about the future, as reflected in the data used in the model: 25X1

- The most recent historical values of those variables that the model is to project may be erroneous, causing the projection to start at the wrong place.
- The projected values of data inputs, required by the model to compute other values, may be incorrect. Because the future is inherently unknowable, such projected values are bound to involve some degree of error that is passed on to the values computed by the model. 25X1

To explore the relative importance of these two errors, we used SOVSIM to make two projections of the Soviet economy in 1982, the last year for which complete historical data were available: 25X1

- For the first projection, we assumed that actual data for 1982 were unavailable. Data inputs, therefore, included values for 1982 that were projected on the basis of average growth rates or trends for the respective variables during a period of years up through 1981. Moreover, model parameters were estimated by using historical data from the 1970-81 period only.
- In the second run, the data inputs included actual observations for 1982, and the model parameters were estimated by using historical data from the entire 1970-82 period. 25X1

25X1

Table 5
Performance in Projecting 1982 Economic Activities

Percent (unless otherwise noted)

Activities	Actual 1982 Value	Deviation From Actual Value Caused by		
		Total Error [a]	Model Error	Data Error
Domestic	*Billion 1970 rubles* (unless otherwise noted)			
GNP	546.8	2.7	0.4	2.3
Growth rate *(percent)*	2.58	80.6	13.2	67.4
End uses				
Consumption	291.8	2.9	−2.3	5.3
Per capita *(rubles)*	1,073.9	3.6	−1.7	5.3
Investment	141.3	0.8	0.3	0.6
Sources				
Agriculture	78.0	6.2	−0.8	6.9
Meat output *(million metric tons)*	15.4	2.7	−1.4	4.0
Nongrain crop output	29.0	−3.3	−1.5	−1.7
Net farm output	90.0	5.9	0.8	5.1
Energy				
Oil output *(million metric tons)*	612.5	−1.4	−0.9	−0.5
Gas output *(billion cubic meters)*	500.8	1.7	1.2	0.6
Industry				
Chemicals	14.8	6.5	3.5	3.0
Machine building	76.3	2.7	0.6	2.1
Industrial materials	46.1	7.8	6.3	1.5
Consumer goods	29.0	−0.5	−0.8	0.3
Services				
Construction	41.6	2.1	−0.2	2.3
Transportation and communication	63.7	3.6	1.9	1.7
Trade and services	153.2	0.0	−1.0	1.0
International	*Billion current dollars* (unless otherwise noted)			
Hard currency				
Trade balance	−0.99	155.2	−11.9	167.0
Credit drawings	2.45	−188.1	−109.8	−78.3
Debt	20.00	−26.6	−1.7	−24.9
Debt service ratio *(percent)*	15.7	−10.8	7.6	−18.5
Communist				
Nonenergy exports	25.86	8.7	2.3	6.4
Nonenergy imports	41.87	6.3	−1.1	7.4
Trade balance	4.58	41.6	16.1	25.6

[a] Components may not add to total because of rounding.

25X1

The results from each simulation were then compared to the corresponding actual historical values for 1982. Any errors in the results of the first simulation reflect total error. For the second simulation, they reflect only model error. The data error alone can be determined by subtracting the model error of the second simulation from the total error of the firs

A sample of the results of this analysis (table 5) suggests that data error was larger than model error in the international and agricultural sectors. Both were in transition in 1982; agriculture had just come through several bad years and the price of energy exports had stopped climbing for the first time since 1978. Data projections for these sectors on the basis of performance in the recent past were unlikely to be good. In the energy sector, model error appears to be larger than data error. In the other sectors of the economy the relative importance of the two kinds of error was mixed. For the economy as a whole and the two end uses given, data error was much larger than model error.

In the productive sectors, total error was relatively small. Output in these sectors was estimated by finely tuned production functions that generally yielded very low model error. The nonagricultural sectors had been fairly stable for several years prior to 1982, permitting data projections to be relatively accurate. Total error for GNP represents an averaging of the errors of the individual productive sectors, but it appears that most of it was due to data problems rather than to the model.

It is not surprising that investment involves much less error than does consumption. Both are estimated as residuals. But the components of investment are both well known and relatively stable. Consumption, by contrast, is estimated using more activities, some of which are difficult to measure accurately. Relatively small errors in these components net out to a relatively large error in the final estimate of consumption.

Trade balance estimates are subject to the same problem: small errors in the components net out to relatively large errors in the residual balances. Because the model uses its hard currency trade balance to estimate credit drawings, the model error for this variable turned out to be quite large

For similar reasons, the GNP growth rate was subject to a large error. Small and unbiased errors in the year-to-year estimates of GNP can result in a much larger error in the percentage change. In our analysis, however, most of the error resulted from data problems.

25X1

25X1

It should be noted that projection errors are peculiar to the period simulated. Economic conditions change constantly. Additional information and intelligence are constantly being made available. Because estimates of input data for a particular year improve as time passes, projections of that year are likely to improve as the year draws closer. Projection accuracy is also enhanced by stability of economic activity

25X1

25X1

25X1

25X1

25X1